Journal of Dental Research
1–7

DOI: 10.1177/0022034520979644
journals.sagepub.com/home/jdr

Mechanisms of Atomization from Rotary Dental Instruments and Its Mitigation

A. Sergis[1], W.G. Wade[2], J.E. Gallagher[2], A.P. Morrell[3], S. Patel[3], C.M. Dickinson[4], N. Nizarali[4], E. Whaites[4], J. Johnson[4], O. Addison[3,4*], and Y. Hardalupas[1*]

Abstract
Since the onset of coronavirus disease 2019, the potential risk of dental procedural generated spray emissions (including aerosols and splatters), for severe acute respiratory syndrome coronavirus 2 transmission, has challenged care providers and policy makers alike. New studies have described the production and dissemination of sprays during simulated dental procedures, but findings lack generalizability beyond their measurements setting. This study aims to describe the fundamental mechanisms associated with spray production from rotary dental instrumentation with particular focus on what are currently considered high-risk components—namely, the production of small droplets that may remain suspended in the room environment for extended periods and the dispersal of high-velocity droplets resulting in formites at distant surfaces. Procedural sprays were parametrically studied with variables including rotation speed, burr-to-tooth contact, and coolant premisting modified and visualized using high-speed imaging and broadband or monochromatic laser light–sheet illumination. Droplet velocities were estimated and probability density maps for all laser illuminated sprays generated. The impact of varying the coolant parameters on heating during instrumentation was considered. Complex structured sprays were produced by water-cooled rotary instruments, which, in the worst case of an air turbine, included droplet projection speeds in excess of 12 m/s and the formation of millions of small droplets that may remain suspended. Elimination of premisting (mixing of coolant water and air prior to burr contact) resulted in a significant reduction in small droplets, but radial atomization may still occur and is modified by burr-to-tooth contact. Spatial probability distribution mapping identified a threshold for rotation speeds for radial atomization between 80,000 and 100,000 rpm. In this operatory mode, cutting efficiency is reduced but sufficient coolant effectiveness appears to be maintained. Multiple mechanisms for atomization of fluids from rotatory instrumentation exist, but parameters can be controlled to modify key spray characteristics during the current crisis.

Keywords: aerosol, SARS-CoV-2, infection control, aerosol-generating procedure, dental drill, imaging

Introduction

A key challenge for the return of global health care systems to "business as usual" is the inherent risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission via emitted sprays (including aerosols and splatter) associated with commonly performed medical and dental procedures. While barrier protection can shield health care providers, the contamination of clinical environments by sprays has led to a need to institute periods of "fallow time," between appointments, to protect patients and staff. Fallow times are dictated by the estimated persistence of an aerosol, which is an inherently multifactorial phenomenon and restricts the use and access of a defined space. Variables include room volume, air exchange rates, airflow vectors, temperature, humidity, and the complex characteristics of the generated aerosol itself. In dentistry, the lack of robust evidence regarding the nature of procedurally generated sprays, contaminated with respiratory or oral fluids, has led to the instigation of extended fallow times, which can challenge the economic viability of current care provision models, as well as restrict patient access to care and the nature of care that can be provided.

At the onset of the coronavirus disease 2019 (COVID-19) crisis, global dental care was effectively reduced to basic management of acute needs, with a focus on exodontia when advice, analgesics, and antibiotics (3As) were insufficient to address pain (CDO-Wales 2020; Hurley et al. 2020; NHS-Scotland 2020). With a deepening understanding of the new virus, the evidence base supporting isolation, distancing, and

[1]Department of Mechanical Engineering, Imperial College London, London, UK
[2]Centre for Host-Microbiome Interactions, Faculty of Dental, Oral and Craniofacial Sciences, King's College London, London, UK
[3]Centre for Oral, Clinical and Translational Sciences, Faculty of Dental, Oral and Craniofacial Sciences, King's College London, London, UK
[4]Dental Directorate, Guy's and St Thomas, NHS Foundation Trust, London, UK
*Co–last authors.

A supplemental appendix to this article is available online.

Corresponding Author:
O. Addison, Faculty of Dental, Oral and Craniofacial Sciences, King's College London, Guy's Tower, Guy's Hospital, London, SE1 9RT, UK.
Email: owen.addison@kcl.ac.uk